REVIEW OF THE SAFETY CONCEPT: PRE-TDR ROADMAP

A. Henriques

FCC Week 2025

22/05/2025

REVIEW OF THE SAFETY CONCEPT: PRE-TDR ROADMAP

gratefully acknowledging the contributions of the FCC Safety WP members:

Ghislain Roy
Giacomo Lavezzari
Guven Nergiz
Markus Widorski
Oriol Rios
Pavol Vojtyla
Thomas Otto
Tomasz Ladzinski

… and the TIWG WG

Outline

- **Safety concept – recap**
- **Review of the Safety Concept**
  - Internal
  - External
- **Review – UK Health & Safety Executive**
- **Safety WP – pre-TDR**
  - Tasks
  - Master plan
- **Conclusion**

FCC Feasibility Study – Safety concept

Future Circular Collider

Feasibility Study Report

Volume 2

Accelerators, Technical Infrastructure and Safety

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Chapter 9

FCC safety concepts

9.1 Introduction

This chapter outlines the safety concept for FCC. Given the intricate nature of particle accelerators, which involve high-energy beams, radio frequency cavities, cryogenic systems, and sophisticated electromagnetic equipment, a comprehensive safety strategy is essential to ensure operational integrity.

Key safety considerations include identifying the scope of the concept, its objectives, as well as the underlying impact of domains such as deep underground siting, radiation protection, structural integrity, fire and oxygen deficiency, and emergency response protocols. Integrating safety measures into the FCC design has an impact on the layout of the facilities. This chapter underlines the specific strategies and technologies employed, demonstrating our commitment to creating a safe and efficient research environment.

9.1.1 Safety considerations

The geographical distribution of surface sites and the time required to reach each site by road, the challenges linked to the underground working conditions, and the diverse composition of technical equipment at surface sites require the systematic development of an integrated safety concept.

The results presented in this chapter are based on work that assumes the *baseline* layout and parameters outlined in this report. If future phases of the study introduce deviations from the *baseline*, their impact on the safety concept will have to be assessed. Certain safety systems form the foundation of the safety concept; therefore, any modifications to these systems may necessitate the development of an entirely new safety concept (see Section 9.3.4).

9.2 Safety goals & objectives

9.2.1 Regulatory framework

CERN, an intergovernmental organisation established under international law by its Convention (1 July 1953, amended 16 June 1972), is headquartered in Geneva and operates across the Franco-Swiss border.

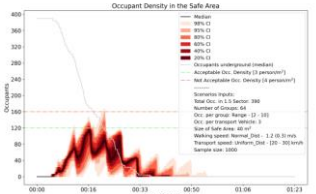
Under its regulatory framework, CERN establishes safety rules as necessary for its functioning. The CERN Safety Policy [421] defines the overarching principles governing safety at CERN and is complemented by CERN-specific rules tailored to its operational needs. Where specific rules are not established, national laws apply within their respective territories. This framework ensures that the rules are uniform throughout the site and adapted to the specific (particularly technical) requirements of the organisation.

CERN collaborates with the Host States under domain-specific treaties and tripartite agreements, e.g., in efforts to minimise environmental impact and uphold best practices in radiation protection. While the Host States facilitate its operations, CERN remains committed to limiting its impact on their territories and ensuring its activities do not compromise their security.

This regulatory framework reflects the current perspective and serves as the foundation for developing this safety concept.

~40% of Technical Infrastructure sections

Fig. 9.5: Personnel transport system [444].



(a) Result of one simulation for scenario 2

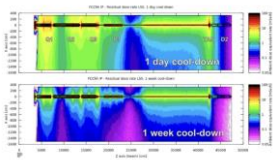
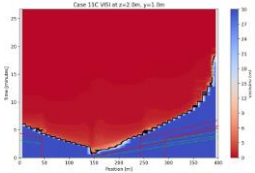


Fig. 9.10: Results showing residual dose rate at FCC-hh IP straight sections after an irradiation of 25 y, with an average collision rate of 5.4×10^{34} p/sec (10 y) + 3.2×10^{34} p/sec (15y). Acceptable positions for the connection of the bypass tunnel are at ~200 m and at ~450-500 m.



(a) Semi-transverse Case 11C [467]

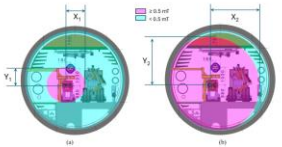
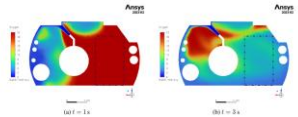
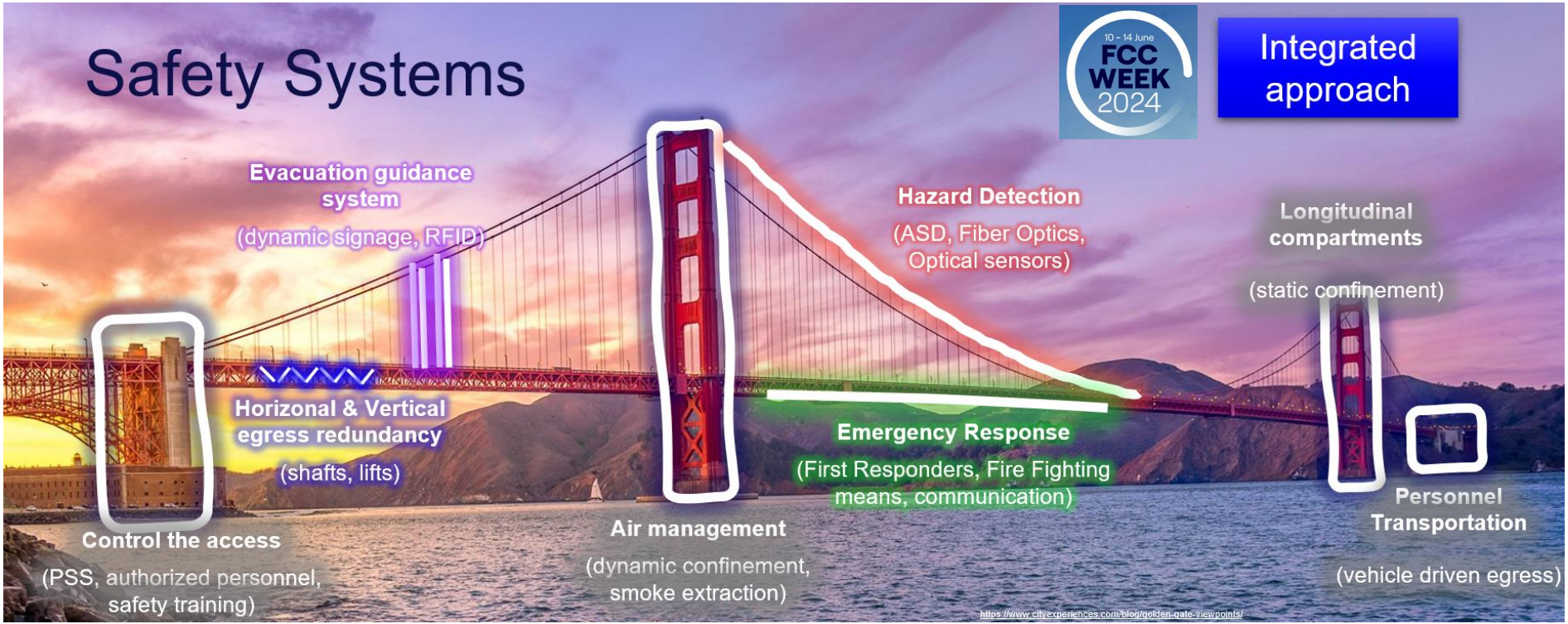


Fig. 9.14: Simulation of stray field envelope at 0.5 mT for the FCC-ee collider arc. a) [illegible] = (1070, 980) mm; b) Quadrupole: (X_2, Y_2) = (2690, 2720) mm

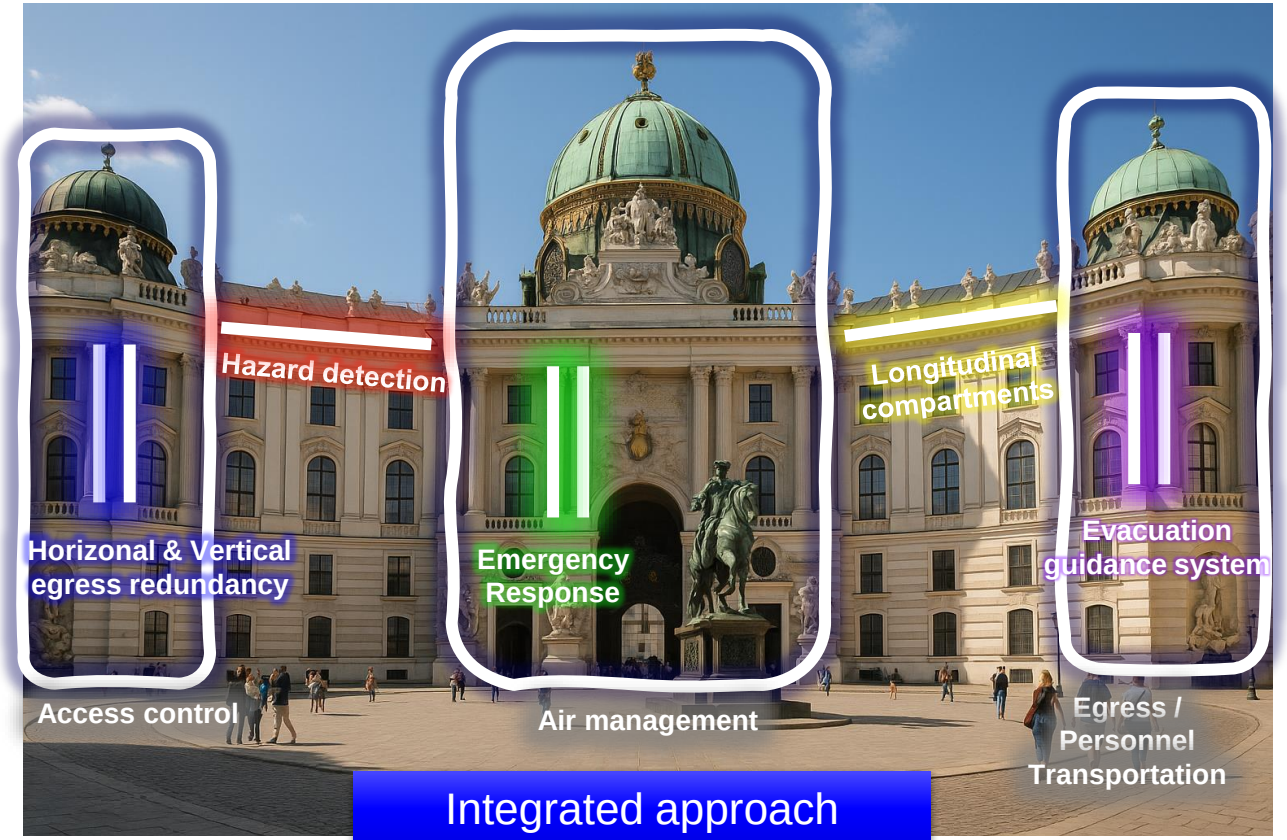


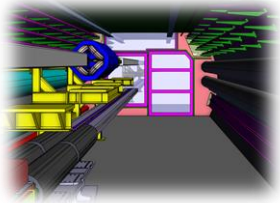
See Safety talks

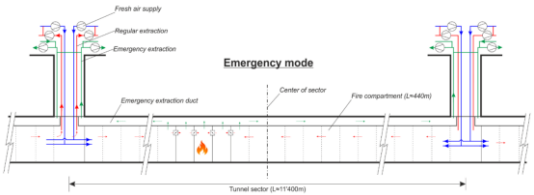
Safety Concept - recap

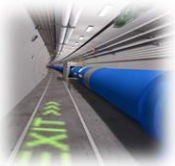


Safety Concept - recap

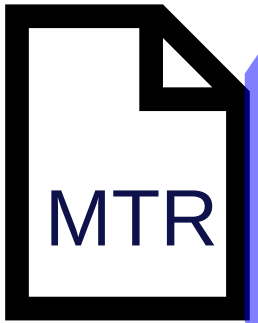








Review of the Safety Concept – Internal



#	Recommendation from MTR	By
1	Clarify operational health and safety requirements for a 10-km-long tunnel with a comparatively small diameter (5.5 m)	SAC
2	Carefully study the risk of ODH in the RF straight sections.	SAC
3	Establish appropriate mitigation measures and procedures early on, as they could impact equipment design.	SAC
4	Carefully plan the evacuation of personnel during an emergency for, e.g., the RF installations and long arcs.	SAC
5	Clearly distinguish between the safety requirements during the construction phase and the requirements for the operation phase	SAC
6	Carry out, at an early stage, a safety risk analysis by specialized external consultants to verify that no important changes in the design are needed	SPC

Source: https://indico.cern.ch/event/1369398/#8-communications

Review of the Safety Concept – Internal

FUTURE CIRCULAR COLLIDER

Scientific Advisory Committee #08

18 Nov 2024, 13:30 → 20 Nov 2024, 14:00 Europe/London

University of Cambridge

Andy Parker (University of Cambridge (GB)), Michael Benedikt (CERN)

PETERHOUSE
UNIVERSITY OF CAMBRIDGE

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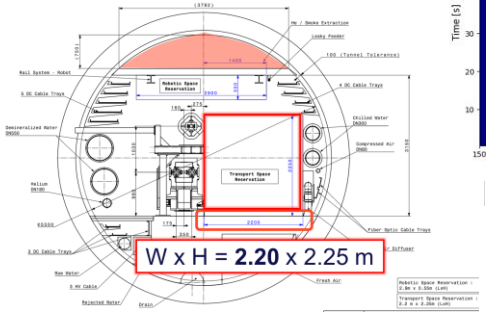
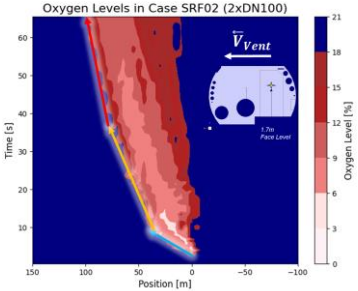




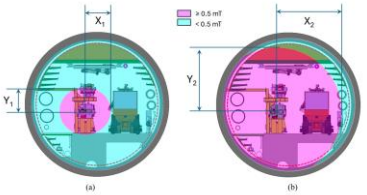
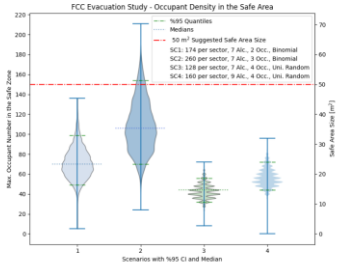
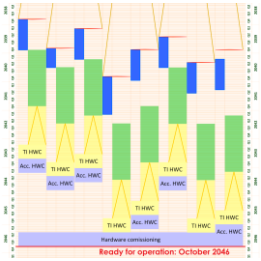


Figure 15: Simulation of stray field envelope at 0.5 mT for the FCC-ee collider arc. a) Dipole: (X_1, Y_1) = (1070, 980) mm; b) Quadrupole: (X_2, Y_2) = (2690, 2720) mm





Review of the Safety Concept – Internal

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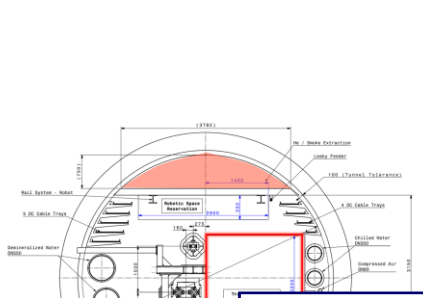
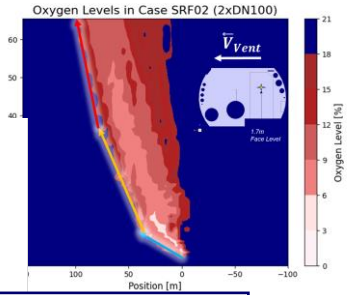
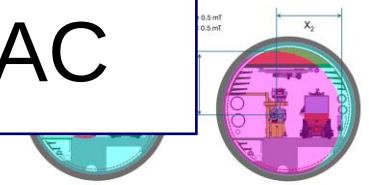
External review





SAC



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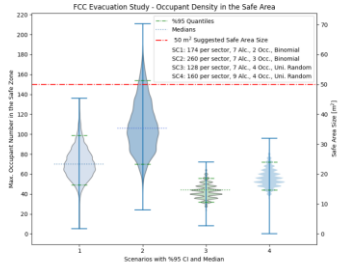

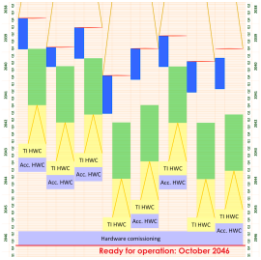

Review of the Safety Concept – External

- Notified body in the member states
- Multi-disciplinary team
- Experience in large infrastructure projects
- Obj #1: Identifying any **showstoppers**

*SPC action: Carry out (…) a risk analysis by external consultant to **verify** that no important changes (…) are required.*

Review of the Safety Concept – External

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- Multi-disciplinary team
- Experience in large infrastructure projects
- Obj #1: Identifying any **showstoppers**

  *SPC: Carry out (…) a risk analysis by external consultant to **verify** that no important changes (…) are required.*

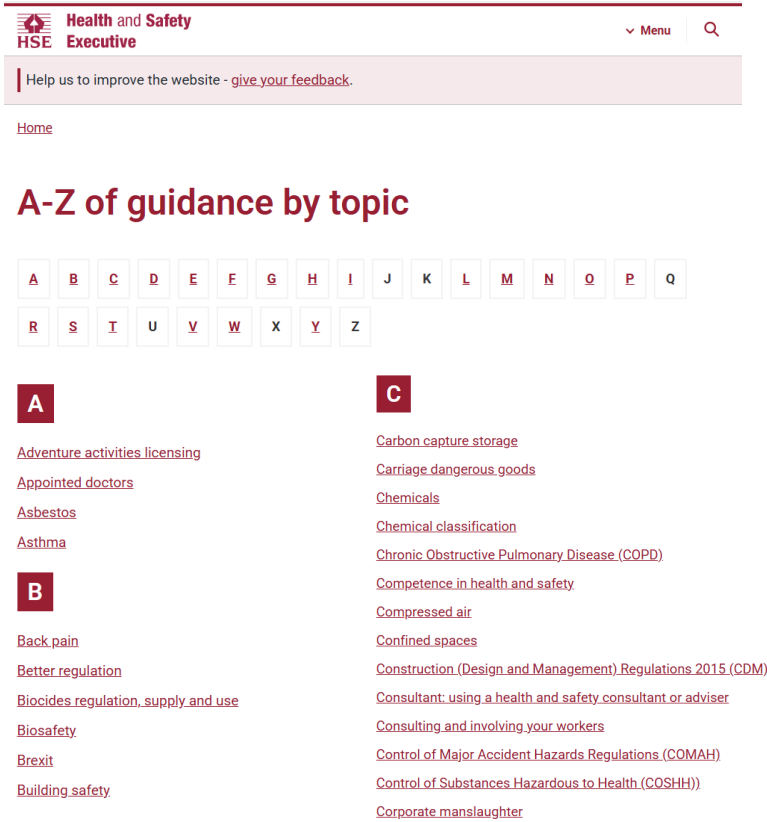
- Obj #2: **Identify improvements**

Review of the Safety Concept – HSE UK

HSE
Health & Safety Executive

Britain's statutory regulator of occupational health and safety

https://www.hse.gov.uk/guidance/topics.htm



HSE Health and Safety Executive — Menu

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A

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Biocides regulation, supply and use
Biosafety
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Building safety

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Carriage dangerous goods
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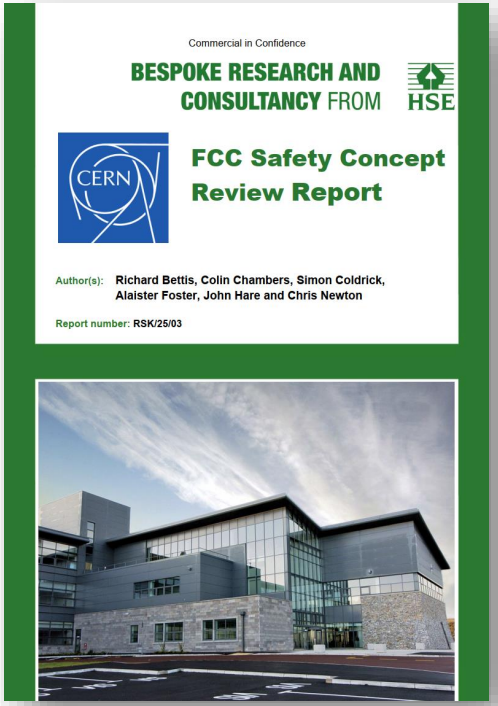
Consulting and involving your workers
Control of Major Accident Hazards Regulations (COMAH)
Control of Substances Hazardous to Health (COSHH))
Corporate manslaughter

Review – UK HSE

Review of all safety domains, except Radiation Protection



https://edms.cern.ch/document/3296700/1

Objective #1

Commercial in Confidence

BESPOKE RESEARCH AND CONSULTANCY FROM HSE

1.3 Key Findings

HSE's evaluation finds no fundamental barriers in CERN's safety report at this stage.

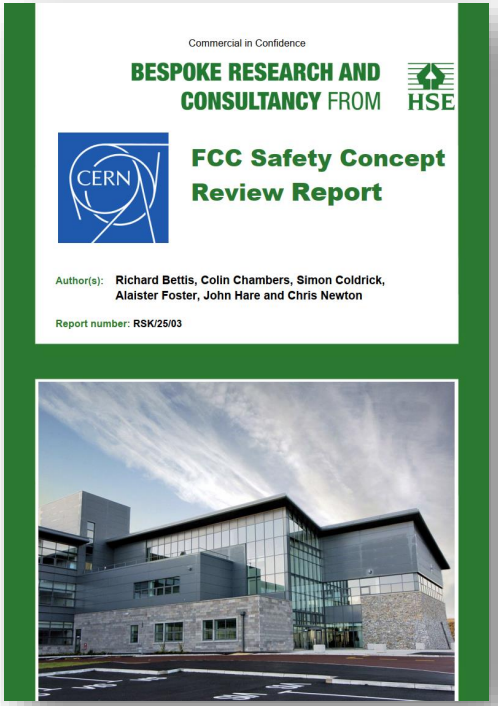
This conclusion is stated with the following caveat:

That the identified safety areas and processes that require further refinement are resolved adequately. → *Objective #2*

Conclusions:

Following HSE's (*UK*) assessment of the CERN Future Circular Collider (FCC) concept safety case, HSE (*UK*) have identified several areas that require further refinement to address potential concerns. CERN's responses [2] reflect a commitment to resolving these issues. CERN have indicated that certain matters have been or will be addressed and as such HSE's evaluation finds **no fundamental barriers in the concept safety report at this stage**. However, this determination is subject to the consideration of HSE's comments and recommendations.

Review – UK HSE



https://edms.cern.ch/document/3296700/1

Objective #2 - TODOs

- Enhanced risk assessments and scenario modelling:
  - *"What if" scenarios*
- Fire / ODH and ventilation interaction studies
- Expand evacuation plan / studies
- Single point failure mitigation in electrical secure power network
- Impact on design changes and technology updates

pre-TDR tasks

Safety WP – pre-TDR

See Safety talks

“What if” scenarios

Failure of Compartment Doors

Door closed during evacuation

Delayed Fire Detection

Lift Failure

Smoke Extraction Failure

Failure in MV Network

Evacuation Alarm Failure

Definition of MCI for SRF

Power Loss

Autonomous Vehicle Malfunction

Vehicle Fire in Alcoves

Seismic hazard

Blocked Escape Routes During Installation phase

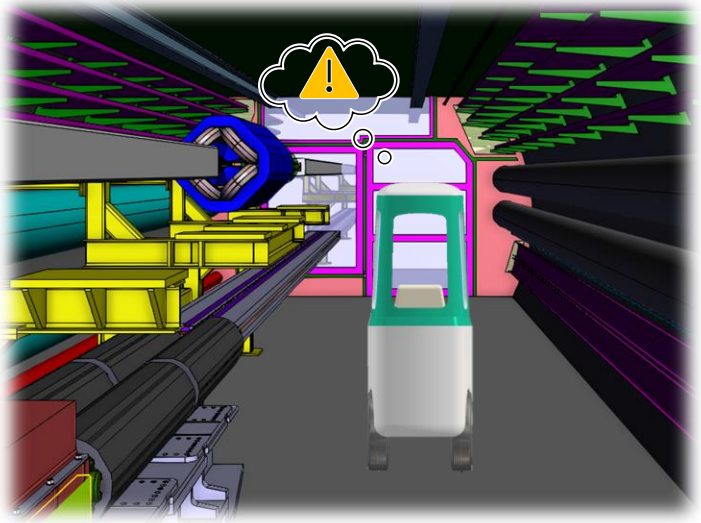
Panic / victims

First task: HAZOP / HAZIDs for all safety domain

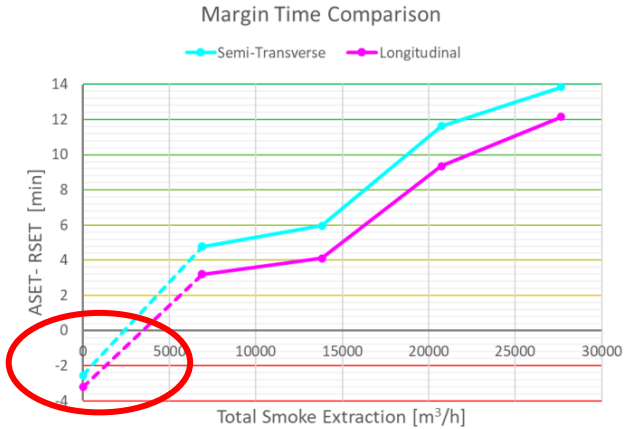
Safety WP – pre-TDR

- *“What if” scenarios - examples*

Door closed during evacuation



Smoke Extraction Failure

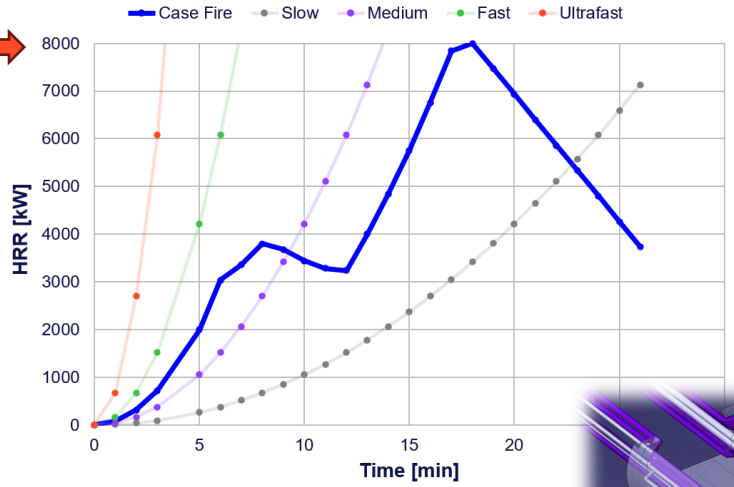


O. Rios et al, FCC Week 2024

See “Reviewed fire safety concept and future studies”, O. Rios

Safety WP – pre-TDR

- Fire / ODH and ventilation interaction studies



O. Rios et al, FCC Week 2024

Table 8.11: Airflow conditions for the tunnel ventilation.

	Air Supply	Regular Extraction	Emergency Extraction
Run and Access mode	2×27 000 m^3/h per sector.	2×27 000 m^3/h per sector.	Standby under pressure operation, no extraction.
Flushing mode	100 000 m^3/h per sector.	100 000 m^3/h per sector.	Standby under pressure operation, no extraction.
Emergency conditions	10 000 m^3/h in affected compartments (max. 2). 3500 m^3/h in adjacent compartments (max. 2). 2160 m^3/h in the rest of the compartments.	Max. 54 000 m^3/h Sharing between the two shafts depends on affected compartment location.	10 000 m^3/h in affected compartments (max. 2). 3500 m^3/h in adjacent compartments (max. 2).

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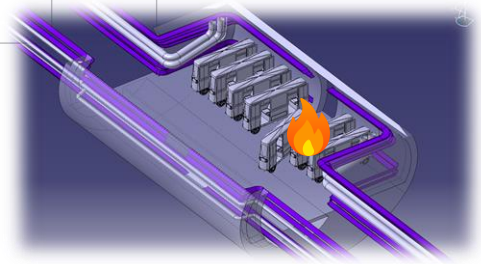
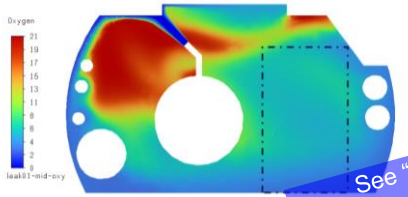


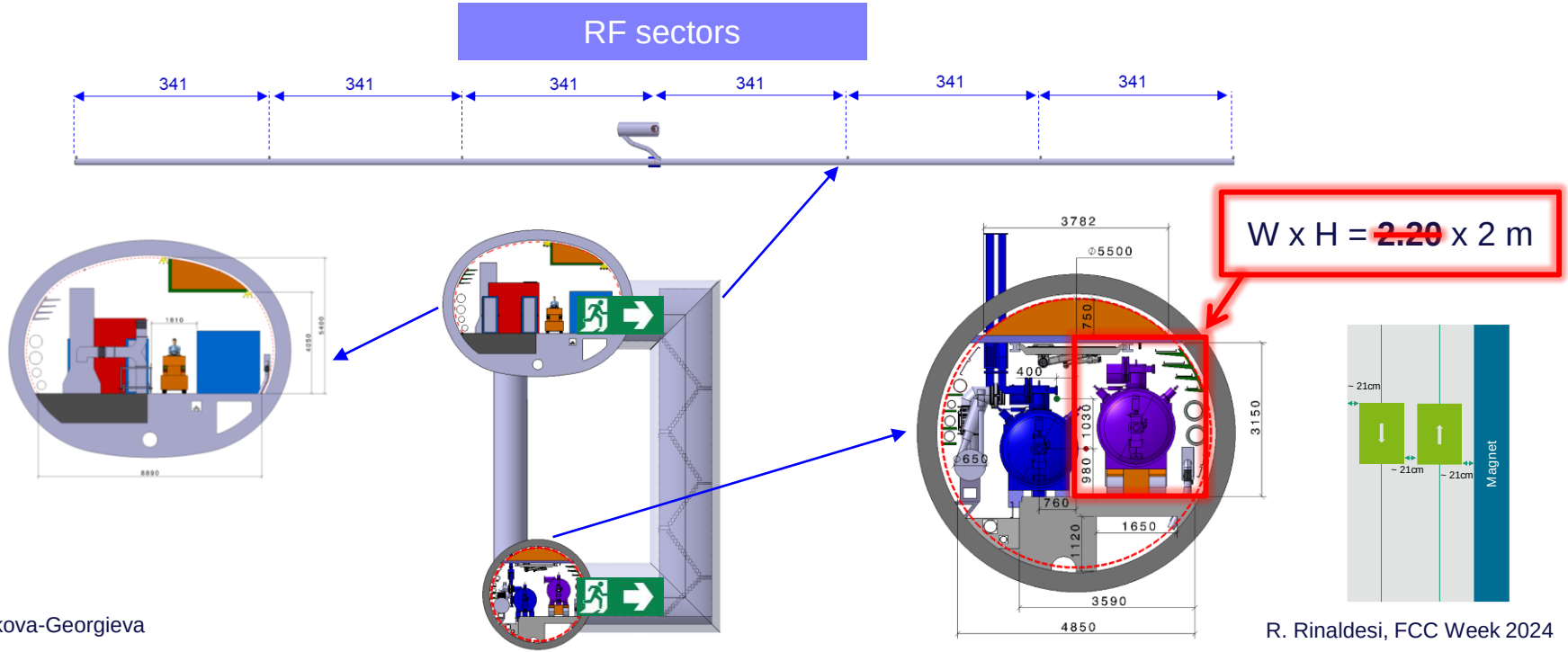
D. Lafarge et al.



See “ODH simulations”, G. Nergiz

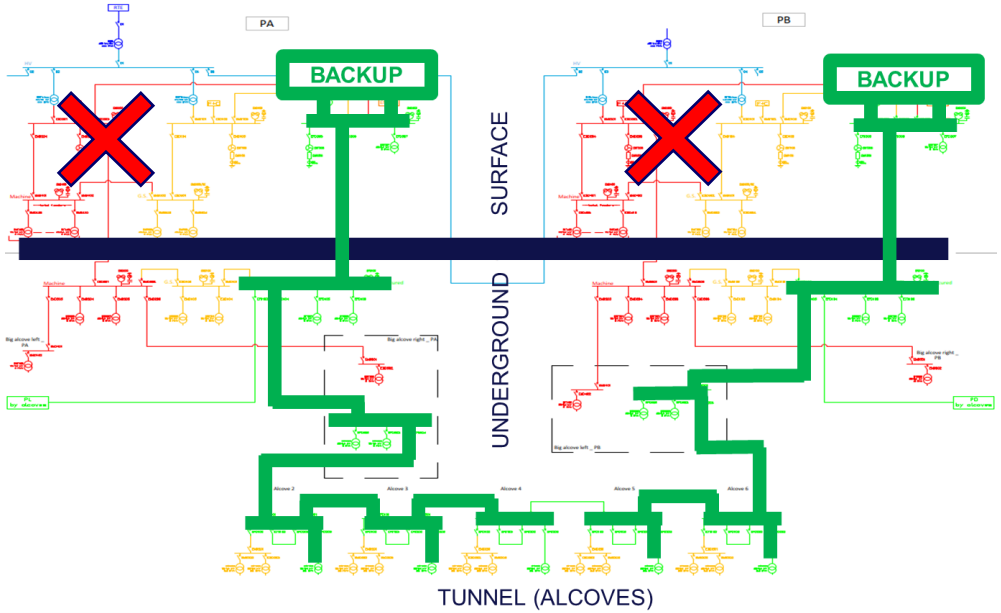
Safety WP – pre-TDR

- Expand evacuation plan / studies



Safety WP – pre-TDR

- Single point failure mitigation in electrical secure power network
  - Secured and uninterruptible network distribution in the tunnel in MV
  - Use the same link (20 kV) for general services AND safety systems
  - Load shedding logic in case of power outage - risk assessment required
  - Power unavailability: 10-30 s



MV line, cables and equipment (switches, etc) in tunnel = **safety standards**

FCC Feasibility Study report, Vol II

C. Marcel,
FCC Week 2025

Safety WP – pre-TDR

Seismic hazard assessment

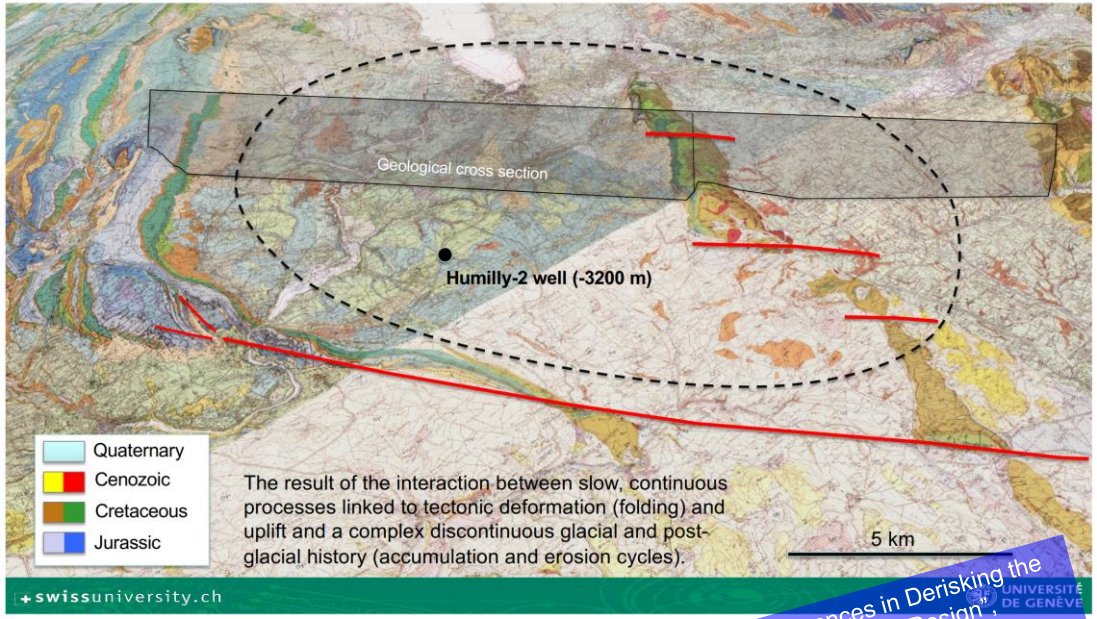
PROJECT MANAGEMENT DOCUMENT

Seismic Hazard Definition for the Future Circular Collider (FCC) Underground Facilities

PROJECT PROPOSAL

ABSTRACT:

In order to provide suitable seismic safety requirements for the design of the structures, equipment and installations foreseen in the underground facilities of the proposed Future Circular Collider (FCC), HSE Unit needs to define a tailor-made seismic hazard at the concerned soil depths. To do so, a collaboration with the Swiss Seismological Service (SED), hosted by the Swiss Federal Institute of Technology of Zurich (ETH), will be established. So far, an unsuitable approach based on the adaptation of the legal seismic safety requirements for ordinary surface buildings on the sole French territory was used to design and assess mechanical structures and equipment in the Large Hadron Collider (LHC) and Super Proton Synchrotron (SPS) complexes, with results that the structural elements could be over- or under-sized to resist to the earthquake loads. This document summarizes the present status of the approach used to design equipment and structures in underground infrastructures at CERN and draws a project-oriented approach to improve the situation by running a seismic hazard study tailor-made for the proposed FCC as well as for the existing LHC facilities. The proposed 3-year project is intended as part of a wider framework. The study illustrated in this document focuses on data collection and the definition of design parameters for strong motion of typical engineering interest; the analysis of weak ground motion and ambient vibration propagation is demanded to a follow-up 3-year project.



Schweizerischer Erdbebendienst
Service Sismologique Suisse
Servizio Sismico Svizzero
Swiss Seismological Service

ETH

UNIVERSITÉ DE GENÈVE

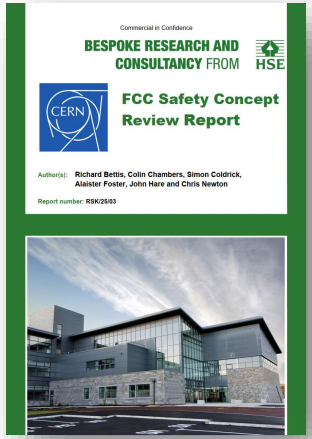
M. Andreini

FCC Feasibility Study report, Vol II

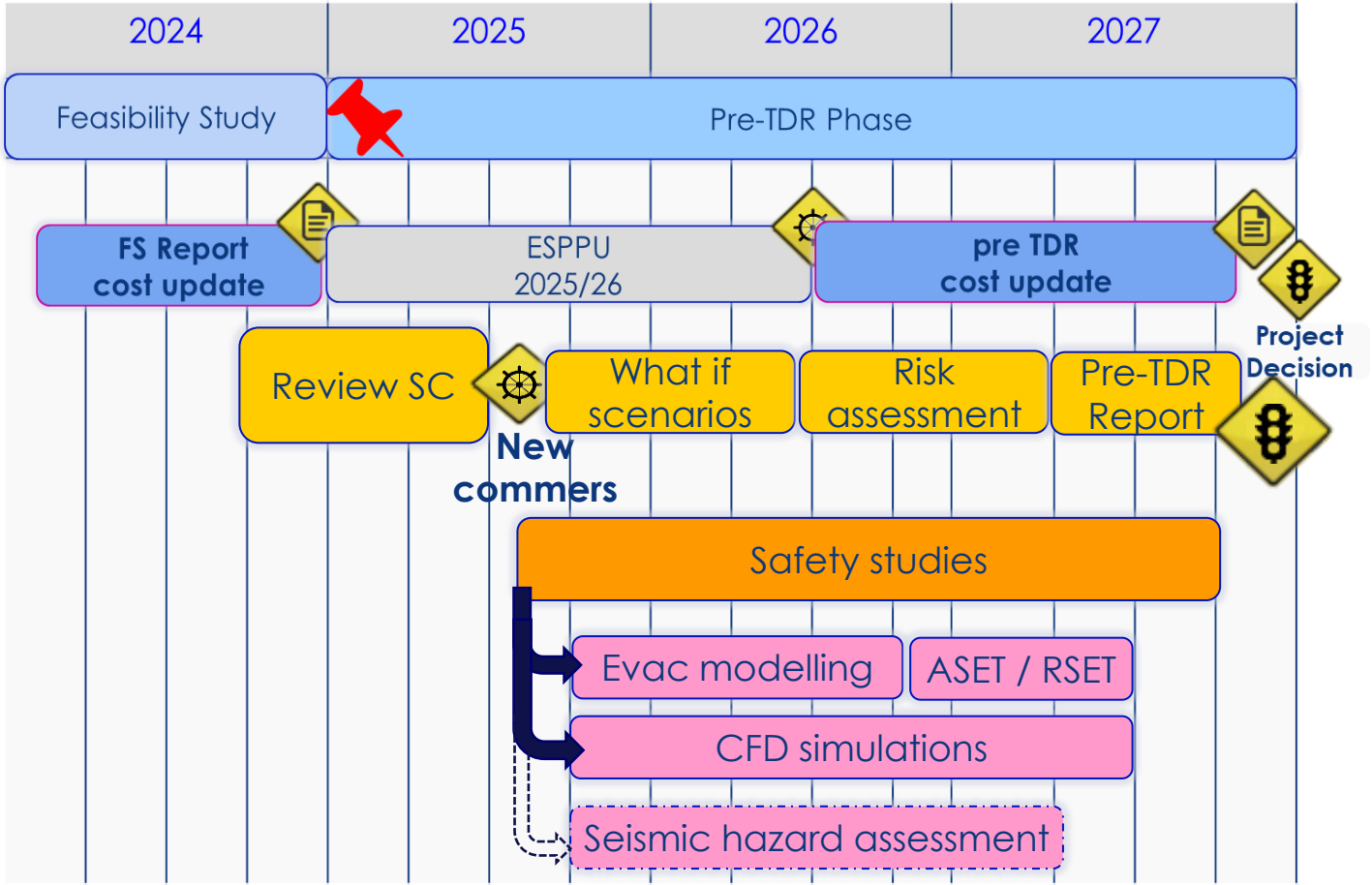
See "Advances in Derisking the FCC Tunnel Design", A. Moscariello

Safety WP – pre-TDR

- CFD studies
  - Mesh sensitivity analysis
  - Benchmarking
- Cyber-physical security
- Ergonomics
- Safety Documentation
- Evacuation scenarios during construction / installation
- Smoke Extraction in Caverns
- PPE
- …



pre-TDR Master Plan



Conclusion

Future Circular Collider
Feasibility Study Report

Volume 2

Accelerators, Technical Infrastructure and Safety

March 31, 2025

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Feasibility confirmed w.r.t Safety

Commercial in Confidence

BESPOKE RESEARCH AND CONSULTANCY FROM HSE

CERN

FCC Safety Concept Review Report

Author(s): Richard Bettis, Colin Chambers, Simon Coldrick, Alaister Foster, John Hare and Chris Newton

Report number: RSK/25/03

Confirmation + pre-TDR work plan

pre-TDR master plan

THANK YOU

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